Turbulence Related Accidents & Incidents

Donald Eick
NTSB Senior Meteorologist
The NTSB is an independent US federal agency charged with determining the probable cause(s) of transportation accidents, making recommendations to prevent their recurrence, conducting special studies and investigations, and coordinating resources to assist victims and their families after an accident.
• An aircraft experiencing severe turbulence does not necessarily make it an accident!

• Did structural damage occur, death, or serious injury?
NTSB Definitions

- **Aircraft accident** - 49 CFR 830.2
- An occurrence associated with the operation of an aircraft which:
  - Takes place between the time any person boards the aircraft *with the intention of flight* and all such persons have disembarked, and in which
  - Any person suffers *death or serious injury*, or in which
  - The aircraft receives *substantial damage*
NTSB Definitions

• Fatal injury
  – Any injury which results in death within 30 days of the accident.

• Serious injury
  – Hospitalization more than 48 hours (within 7 days);
  – Bone fractures (except simple fingers, toes, or nose);
  – Severe hemorrhages, nerve, muscle, or tendon damage;
  – 2\textsuperscript{nd} or 3\textsuperscript{rd} burns, or more than 5\% of body surface;
  – Any internal organ.

49 CFR 830.2
NTSB Definitions

• **Substantial Damage**
  - Adversely affects structural strength, performance, or flight characteristics, and which
  - Would normally require major repair or replacement of affected component

• **Exclusions**
  - Engine failure or damage limited to 1 engine (two or more)
  - Bent fairings or cowling
  - Dented skin
  - Small punctured holes in the skin or fabric
  - Ground damage to rotor or propeller
  - Damage to landing gear, wheels, tires, brakes, flaps, engine accessories, or wingtips

49 CFR 830.2
NTSB Definitions

• Incident
  – Occurrence other than an accident associated with the operation of an aircraft, which affects or could affect the safety of operations
  – Majority of turbulence events occur in this category!
  – NTSB May or may not be involved, crew incapacitation, infant injured, special issues…
Weather related accidents have one of the highest fatality rates.
NTSB 2012 Accident Statistics

Part 91 - General Aviation

• **1,471** accidents
• **271** fatal accidents
• **432** total fatalities
• Accident rate **6.78** per 100,000 hours
• Part 91 accounted for 51% of total flight time and 97% of all fatal accidents
• Majority of the fatal accidents occur in instrument meteorological conditions (IMC)
Defining Part 91 Fatal Accident Events

- Loss of Control (LOC) in Flight
  - In-flight breakups
  - Turbulence/Weather encounters
- System/Component Failure – Powerplant
- Controlled Flight into Terrain (CFIT)
- Collision with Terrain/Object (non-CFIT)
- VFR Encounter with IMC
- System/Component Failure – Non-Powerplant
Review of Part 91
In-flight Breakups 2000-2013

Review of 86 loss of control (LOC) accidents which resulted in-flight breakups

<table>
<thead>
<tr>
<th>Category</th>
<th>Events</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFR into IMC</td>
<td>21</td>
<td>54</td>
</tr>
<tr>
<td>Flight into TSTMS</td>
<td>17</td>
<td>39</td>
</tr>
<tr>
<td>IMC/Clouds/Icing/turb</td>
<td>12</td>
<td>31</td>
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<tr>
<td>Turbulence/MTW</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Spatial Disorientation/Night</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Wake Turbulence</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Maneuvering/Aerobatics</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Structural Issues</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Pilot Incapacitation</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

86 events 180 fatalities
Part 121 – Air carrier Weather Related Cause/Factors 2000-2011

- Turbulence: 71%
- Adverse Wind: 14%
- Icing: 1%
- TSTMS: 6%
- Precip: 5%
- Freezing rain/sleet: 1%
- Windshear: 1%
- Fog: 1%

446 Accidents

Non-Wx Related: 63%
Weather Related: 37%
Turbulence has caused more serious injuries to passengers than any other class of accident.
NTSB Investigations

- Notification often limited data – event location
- Synoptic conditions – define basic conditions
- Upper air data - Sounding, AMDAR, Model data
- Satellite imagery
- Weather Radar – WSR-88D/TDWR/CoSPA, lightning
- PIREPs
- NWS Forecasts & in-flight weather advisories
  - Turbulence/convective model/guidance products
- Weather briefing data – dispatch, flight updates
- Statements/Witnesses – crew coordination
NTSB Investigation

• Other data sources used when available:
  – Aircraft CVR/FDR data – vertical accelerations forces or g’s quantifiable data
  – AMDARs – EDR values

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Airspeed Fluctuation (knots)</th>
<th>Vertical Acceleration (g)</th>
<th>Derived Gust (fpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>5 – 14.9</td>
<td>0.20 – 0.49</td>
<td>300 - 1,199</td>
</tr>
<tr>
<td>Moderate</td>
<td>15 – 24.9</td>
<td>0.50 – 0.99</td>
<td>1,200 – 2,099</td>
</tr>
<tr>
<td>Severe</td>
<td>≥ 25</td>
<td>1.0 – 1.99</td>
<td>2,100 – 2,999</td>
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<tr>
<td>Extreme</td>
<td>-</td>
<td>≥ 2.00</td>
<td>≥ 3,000</td>
</tr>
</tbody>
</table>
NTSB Investigation

- Man-Machine-Environment
- *Major issues* to identify
  - Was the weather conditions properly forecast
  - PIREPs or other observations available
  - Advisories issued
  - Role of controller, dispatcher, flight crew in mitigating event
Turbulence Classification

- Clear Air Turbulence (CAT)
- Convectively Induced Turbulence (CIT)
- Mountain Wave (MWT)
- Mechanical (LLT)
- Vortex Wake
- Gravity Waves
Hurt during flight turbulence, she’s paralyzed after breaking her neck in airplane bathroom. …Airline says fasten seat belt sign on.
The vast majority of Part 121 turbulence events are associated with Convectively Induced Turbulence (CIT)

Still occasionally reported as CAT encounters
## Significant Turbulence Incidents & Accidents
### Part 121 Air Carriers 1998-2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
<th>Serious</th>
<th>Minor</th>
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<tbody>
<tr>
<td>2013</td>
<td>11</td>
<td>3</td>
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<td>2012</td>
<td>33</td>
<td>10</td>
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<td>26</td>
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<td>2010</td>
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<td>1999</td>
<td>36</td>
<td>16</td>
<td>181</td>
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<tr>
<td>1998</td>
<td>34</td>
<td>22</td>
<td>111</td>
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</tbody>
</table>

### Averages
- **Events**: 26.9 annually
- **Serious injury**: 14
- **Minor injury**: 69

### 2009 significant events:
- B747 over Pacific Ocean: 42 injuries
- B767 over Atlantic Ocean: 33 injuries

### Sources:
- NTSB, FAA incident & accidents
- The Aviation Herald, Curt Lewis LLC briefs
Air Carrier Turbulence Events

• Turbulence rarely causes fatalities; however, fatal events have occurred:
  – (2) B737 India      CIT    May 10, 1980
  – (85) L-188 Texas     CIT    May 3, 1968
  – (124) B707 Japan     MWA    Mar. 3, 1966
  – (1) Caravelle, TN    CIT    July 8, 1964
March 3, 1966
BOAC B-707 flight 911
At FL170 encountered mountain wave turbulence which resulted in-flight break up near Mt. Fuji, Japan.
Fatal 124

- Weather station base of Mt. Fuji reported winds 60-70 KT
- Satellite imagery showed formation of rotor and lenticular clouds
- PIREPs – numerous reports of moderate-severe turbulence
- U.S. Navy aircraft encountered extreme turbulence +9g to -4g
Encountered with severe-to-extreme turbulence and resulted in an in-flight breakup, fatal to 39.
Total incidents reported 33, only 9 were defined as accidents due to serious injuries and most only limited NTSB investigations.

2012 Turbulence Accidents (9)

- CEN12LA166 – Detroit, MI, B737, 1 serious, 4 minor
- WPR12LA119 – Pawnee, NE, B737, 1 FA serious
- WPR12LA144 – Laverne, OK, B737, 1 FA serious
- DCA12FA062 – Buena Vista, CO, A319, 2 serious, 1 m
- DCA12FA069 – Ft. Lauderdale, FL, A319, 1 FA serious
- DCA12FA086 – Atlantic City, NJ, B757, 1 FA serious
- DCA12FA091 – Winne, TX, B737, 2 FA serious
- ERA12LA498 – Hilton Head, SC, ERJ, 1 PAX
- DCA12CA149 – Sophia, NC, A330, 1 serious, 2 minor
• Total 11 air carrier turbulence incidents reported
• 3 turbulence accidents, with 3 serious injuries

• 2013 Turbulence Accidents (3)
  – WPR13LA131 – Pacific Ocean, B747-400, 1 FA serious  Feb. 19
  – WPR13LA431 – Reno, NV, DHC-8, 1 serious, 2 minor  Sept. 29
  – DCA13CA014 – Houston, TX, B767, 1 FA serious  Nov. 21
NTSB 2014 Turbulence Events

• 15 air carrier turbulence events recorded, 1 accident
  – DCA14LA060 – Billings, MT, United Airlines B737, 11 injured, 2 serious on Feb. 17, 2014
  – United Airlines DEN-BIL
  – FL340 encountered severe turb
  – Infant flung from mother’s arm
  – 3 FA injured; severe head wound
  – Emergency declared
Mountain Wave Activity

• Mountain wave activity (MWA) continues to cause accident/incidents

• 2008 Continental Airlines B737 runway excursion accident in Denver, CO

• The NTSB issued Safety Recommendation A-10-105 to the FAA on furthering understanding of the effects of MWA and related wind events.

• 2009 French B737 loss of control event in Turkey
  – During the event, the airplane lost about 3,500 ft of altitude, and its maximum recorded descent rate was about 12,000 fpm.
  – The French BEA quantified general mountain wave conditions and indicated that “Making the crew aware of potential mountain waves meteorological conditions over high ground would have made them more vigilant…”
DCA09MA021
Continental Airlines B-737
Runway Excursion
Denver, CO
December 20, 2008

- Boeing B-737 crosswind limit: 40 KT
- Airlines crosswind limit: 33 KT
- Accident winds: 270° 45 KT
NCAR Clark-Hall Numerical Model

X–Z plot at lat 39.88

U min,max -8.2 91.5
Area of high winds reaches surface
NCAR Clark-Hall Numerical Model

X-Y plot at 14.7M AGL 49 UTC

U (m/s) min,max -6.8 34.8

40 KT
Owens Valley, CA during Sierra Rotor Project 2005

Mountain Wave Cases of interest
United Airlines B-737
Colorado Springs
March 3, 1991

• Airspeed fluctuations 139 to 160KT
• Severe turbulence 0.6 to 1.6 G’s
• Aircraft banked right, rolled inverted, and impacting the ground
• Rotor potentially initiated the event or flight upset
• Rudder hard over – jam in main rudder power control unit servo value
DC-8 encountered SVR-EXTRM CAT over Colorado on December 9, 1992.
In-flight engine separation Japan Airlines
B747 Anchorage, Alaska
March 31, 1993

Evergreen Airlines
Evergreen B747 engine after it separated due to turbulence
The pilot's inadvertent flight into mountain wave weather conditions while IMC, resulting in a loss of aircraft control.
The aircraft passed the VORTAC at 15,000 feet when ABQ controllers heard a "MAYDAY" call, and radar contact was lost with the airplane at 14,700 feet.

SIGMET Whiskey in effect for severe turbulence and mountain wave activity.

PIREPs confirmed turbulence & mountain wave conditions existing across region:

- ABQ UA /OV CIM/TM 2300/FL 370/TP B757/TB STG MTN WAVE +/- 30KT
- TCS UA /OV TCS/ TM 2330/FL 100/TP BE58/TB MOD-SVR
Band 3 moisture channel darkening
Wind
270° 50kt

Rotor clouds
DEN06FA132 – Telluride, CO
September 15, 2006
Beech Debonair, N5893J

- Part 91 – VFR flight
- Taos, NM – Telluride, CO
- LOC at 15,000 ft
- Fatal 5
- Probable Cause: inadvertent flight into mountain wave turbulence resulting in loss of control of the airplane and subsequent impact into mountain terrain
WPR13FA072 – Payson, AZ
Dec. 18, 2012
Piper PA-31, N62959

- Ameriflight 3853 (UPS)
- Part 135 Cargo Flight
- IFR flight plan
- Dep: Holbrook to Payson with final destination PHX
- No official weather briefing – knowledge of weather unknown
- IMC prevailed with full series of AIRMETs current for area
- At 13,800 ft reported encountering strong updraft/downdraft to ATC before loss of radio contact
- Fatal 1